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Author: Mr. Luigi Renzulli
Politecnico di Torino, Italy

Mr. Samuele Ferrero
Politecnico di Torino, Italy
Mr. Paolo Garelli
Politecnico di Torino, Italy
Mrs. Beatrice Lanteri
Politecnico di Torino, Italy
Mr. Domenico Martinelli
Politecnico di Milano, Italy
Mr. Enrico Masiero
Politecnico di Milano, Italy
Dr. Alberto Rosso
Politecnico di Torino, Italy
Dr. Valentina Sumini
Politecnico di Milano, Italy
Dr. Andrea Giovanni Mainini
Politecnico di Milano, Italy
Prof. Amedeo Manuello Bertetto
Politecnico di Torino, Italy
Dr. Maria Antonietta Perino
Thales Alenia Space Italia, Italy
Mr. Walter Cugno
Thales Alenia Space Italia, Italy
Dr. massimo c comparini
Thales Alenia Space, Italy
Mr. Alessandro Oliveri
Italy
Dr. Francesca Ortolani
Italy

COSMICA PROJECT: ADVANCING ASTRONAUT SURVIVAL AND WELL-BEING THROUGH MICROALGAE-BASED DESIGN

Abstract

NASA Artemis program represents the most significant upcoming space exploration mission that will entail the direct involvement of human beings in harsh and inhospitable environments. The primary challenge confronting the scientific community is ensuring the survival and well-being of astronauts. Microalgae-based technology presents itself as a promising approach to address this challenging

issue, providing a range of advantages such as oxygen generation, carbon-dioxide reduction, radiation protection, and the creation of nutrient-dense superfood. Additionally, an innovative lighting system leveraging microalgae could facilitate a connection with nature and provide psychological benefits for astronauts amidst the challenges of space exploration. The Cosmica project prioritizes human comfort by using microalgae-filtered green light to create a calming environment, potentially mitigating psychological stress and boosting immunity and physical performance. An important advantage of using algae is the production of superfoods: spirulina offers a valuable nutrition source for astronauts with its rich protein and vitamins content. The project focuses on improving the taste and overall sensory appeal of spirulina to make it more attractive and palatable. To harness the benefits of microalgae effectively, a highly adaptable and user-friendly component has been designed. This component has been conceived modular, aimed at maximizing adaptability to various spatial configurations. To reduce unused internal space, its structure incorporates multiple photobioreactors, interspersed with LED strips, and includes both hydraulic and electronic systems. These design choices enhance user experience, ensure reliability, and facilitate maintenance. In addressing the design of the photobioreactor a fluid dynamics analysis was performed using the software STARCCM+ to optimize the recirculation and gas injection for cultivation compatibility and efficiency. A thermal analysis is also essential to ensure adequate heat dissipation from LED-strips irradiation, maintaining temperature conditions within photobioreactors that are favorable for their use. Moreover, a radiation analysis was conducted to demonstrate a key feature of the component: containing mostly water, photobioreactors constitute an efficient radiation shield. The incorporation of hydraulic systems alongside photobioreactors is crucial in boosting the productivity and sustainability of microalgae.This integrated approach enhances nutrient distribution, enables efficient mixing, and addresses challenges like pH-variations, thereby improving the overall biomass yield and quality. To showcase the full range of the component's capabilities, a demonstrator was created. In conclusion, the suggested design has the potential to be a perfect fit for future space exploration missions as a key element of a self-sustaining habitat for humans. Additionally, it could serve as a valuable asset in Earth's extreme environments.